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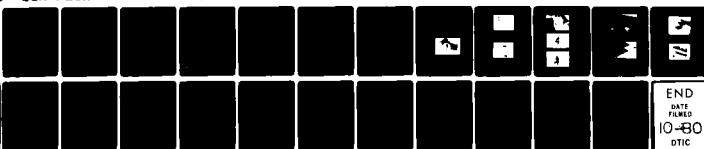
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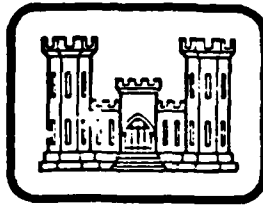
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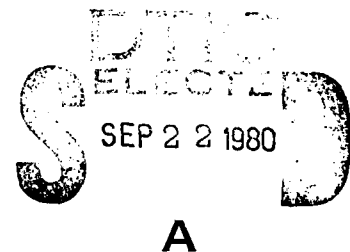
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INFRARED UTILIZATION

25 April 1980

Final Report



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## INFRARED UTILIZATION

### 1.0 INTRODUCTION

The purpose of this report is to present some information regarding the use of infrared (IR) instrumentation and to inform the Facilities Engineer where such use may be technologically feasible and cost-effective. At present, the state-of-the-art is such that infrared thermography will quantify radiative heat losses but will not quantify total building heat losses. Quantitative measurements are expensive, time consuming and difficult. However, when used or interpreted by experienced personnel, infrared instruments are useful diagnostic tools.

### 2.0 DISCUSSION

Infrared devices, whether airplane mounted photographic scanners or hand-held thermal radiation probes are basically devices dependent on the intensity of energy radiated in a given wavelength band. When they have scales, they indicate the apparent temperature differences on the surface at which they are aimed or they may indicate the temperature differences between the surface and a built-in standard. However, the readings only indicate the radiation temperature of the surface. Temperature is only one variable in the heat transfer equation. Heat is lost from the building by both radiation and convection. For a determination of these losses, the emissivity, the reflectivity, and conductivity of the walls and roof must be known in addition to the temperature. Figures 1 and 2 are illustrative of the problems involved in trying to quantify heat loss using IR equipment.

2.1 The question of cost effectiveness must be considered since modifications and retrofit of buildings is costly. The savings in fuel costs from re-insulation or modification must be large enough to amortize the cost of the repair and the cost of the IR surveys. Infiltration air in a typical building may account for 40 to 60 percent of the building cooling or heating loss. Losses through walls could be a small percentage. A large amount of productive usage is required to amortize, cost effectively, a 40 thousand dollar IR instrument. Rental of the equipment, procurement of the inspection service, obtaining the service from FESA, or a joint (multi-installation) purchase of the equipment should be analyzed to determine the most cost effective method of accomplishing the task.

2.2 For the present, when qualitative answers are satisfactory, or where radiation temperature differences in themselves are significant indications of trouble, infrared devices make excellent diagnostic aids. One

highly remunerative use of infrared scanners and probes is in connection with the periodic inspection of electric transmission and distribution lines and associated equipment. Loose connections, over-loaded transformers, defective high-voltage switchgear, and other similar problems are readily detected with an infrared scanner (Figure 3, 4). Most importantly, the entire inspection can be accomplished without shutting down any of the power lines. Inspection damage, which often occurs when the joints are mechanically torqued, is completely avoided.

2.3 One use of the infrared scanning which can provide an immediate payoff is in the detection of moisture in the insulation of a flat, built-up roof (Figures 8 through 10). Here there is no quantitative question involved. The location of unwanted water is the pertinent factor. Even though the scanner cannot be used in the daytime because of signal to noise problems caused by the sun, it can be used at night in either the summer or winter. There are two contributing effects. One, heat leaking through the roof from the interior of the building selectively raises the temperature of the more highly conductive wet insulation. Two, the sun's heat raises the roof temperature during the day. At night the wet insulation acts as a heat sink and the surface temperature over the defective insulation is higher than the surrounding roof and the wet spots under the roofing felts can be seen. The method appears to be cost effective since early detection and location of roof leaks can save large amounts of money later on. It is also effective in determining whether a roof can be patched or needs total replacement. Aerial scanning and hand devices are presently being utilized by FESA. The number and extent of the roofs must be considered. So far, work has indicated that aerial scanning will point out places that are candidates for hand-held scanner inspection. From the air, it is difficult to tell the difference between water on the surface of the roof and water under the felts. Nor can differences in radiation temperatures due to different surface emissivities be accounted for. Even when walking a roof with a hand-held device, the answers concerning temperature differences are not always immediately apparent. Varying thicknesses of bitumen cause erratic results. The presence of heated devices, pipes, and ducts, for example, have also given preliminary false indications on the scanner. The time of day, the day and night ambient temperatures, whether or not the building is air-conditioned or heated, and the wavelengths used in the scanner are some of the factors which contribute to the problem of interpreting the IR scans. It appears now that a hand-held infrared scanner is a very effective way to non-destructively test for the presence of water in built-up roofs. The moisture meter can be used during the day but is more time consuming than infrared techniques. Used in conjunction with aerial infrared photography the time to survey can be cut down. Although the nuclear meter has a higher operating cost than the hand-held IR scanner, consideration must be given to the fact that the nuclear meter is significantly less costly than the IR instruments.

### 3.0 CONCLUSIONS

Infrared thermography has shown its value in a number of applications. It can assist in determining the pattern of power plant hot water effluent in a stream and has been used to detect changes in agricultural growth. It can be used to locate underground steam and hot water lines and leaks (Figure 11 to 15). It cannot pinpoint the location of a leak in systems whose pipes are installed in conduit. Steam traps can be inspected very quickly (Figures 5 through 7). For example, a laundry with 200 steam traps can be inspected by a walk through type survey in 3 to 4 hours. It is recognized that defective steam traps can be identified by relatively unskilled personnel using heat crayons or similar cheap indicating devices. Infrared probes, which are relatively cheap, can also be used. However, if an IR viewer is available, its use is the fastest and easiest method of inspecting steam traps. A programmed inspection of an installations electrical systems (anticipatory maintenance), steam traps, hot water and steam lines, flat roofs, and energy consuming buildings, could be beneficial and cost effective.

### 4.0 RECOMMENDATIONS

IR scanning devices are tools which can be used effectively. However, there is no substitute for an experienced operator who can make "on the spot" judgements related to causes and effects and pursue elusive clues immediately.



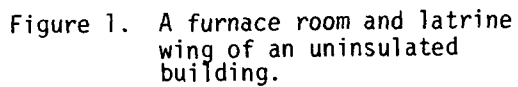


Figure 1. A furnace room and latrine wing of an uninsulated building.



Figure 2. Heat escaping from open latrine window is noticeable. Because of wind induced turbulent air flow on end of building, it appears to be losing less heat than side protected from wind, where air flow is mostly laminar. Actually, most of the heat loss is from the wind swept side of the building. Quantitative determination of heat loss is not possible using the IR equipment alone.

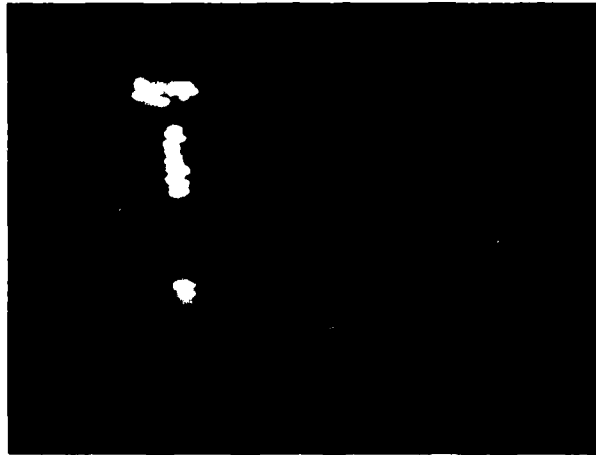


Figure 3. IR view of a high voltage fuse in sub-station. Fuse is over-heated and fuse holders are dirty.

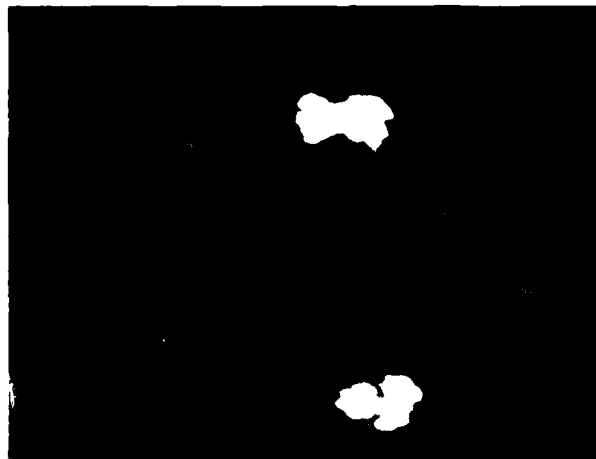


Figure 4. IR view of over-heated fuse holders in sub-station. New equipment made possible these views on a sunlit day.



Figure 5. Steam trap in laundry.



Figure 6. Good steam trap in IR viewer. Outlet line is cooler than inlet.



Figure 7. Bad steam trap. Note steam in condensate line.



Figure 8. Marked off area on leaking roof.

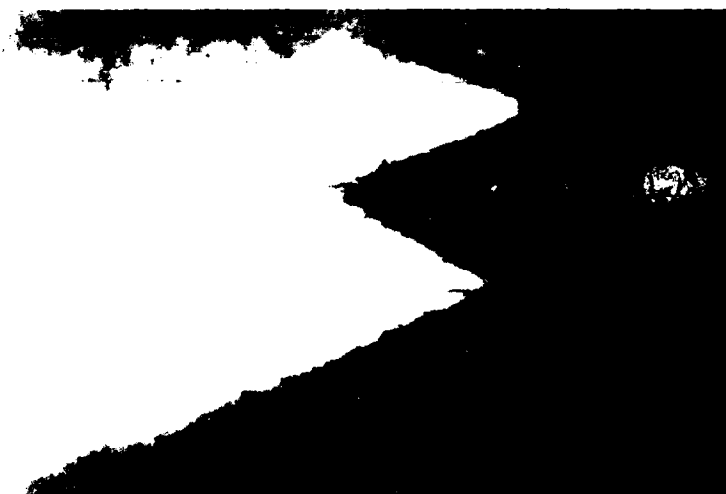


Figure 9. IR view of area shown above.

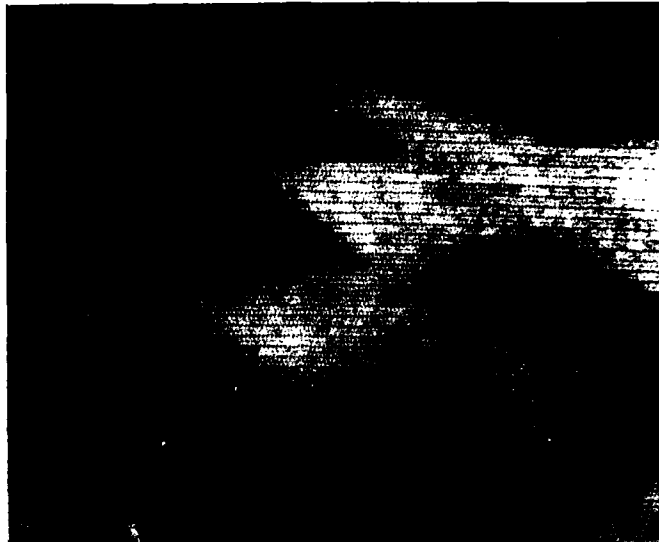


Figure 10. IR view of a roof section which is leaking. Water is being held by individual insulation blocks which are separated by bitumen that has flowed down between them.



Figure 11. Break in unconduted, insulated, low temperature heating line buried under macadam street. Note that heat trace narrows down as the distance from break becomes larger. Straight white line behind trace is curb. Other white is foliage in background.

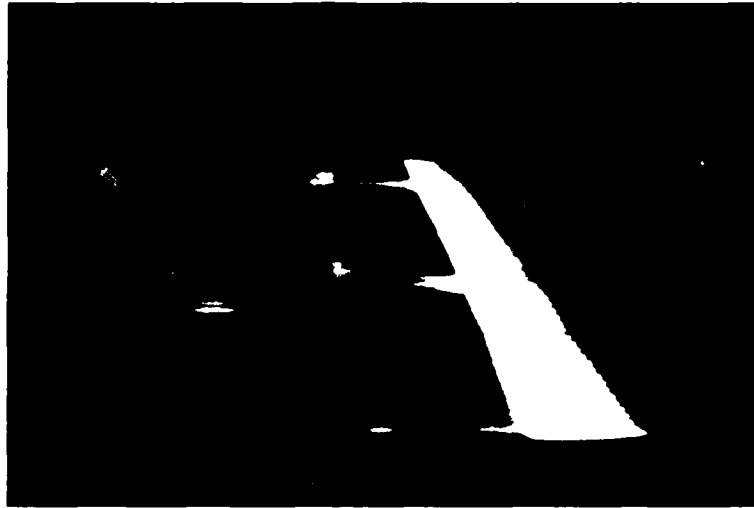


Figure 12. Sidewalk over broken HTW line.

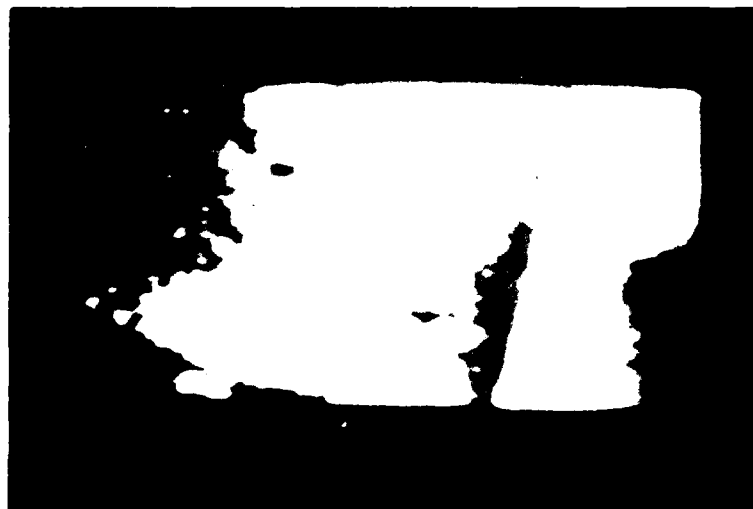


Figure 13. HTW line at corner where break was suspected. This was the lowest point in conduit. Actual pipe break was an eighth of a mile away.



Figure 14. Aerial IR view used to find location of buried pipe.



Figure 15. Aerial IR view showing pipe trace.

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